Emerging technology dominance: what China's pursuit of advanced dual-use technologies means for the future of Europe's economy and defence innovation

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In its quest to become a global 'science and tech superpower' and to build a strong military that can fight and win wars, China has embarked on a major process to achieve civil–military integration (CMI) and develop advanced dual-use technologies. Using various methods both to promote indigenous innovation and to access foreign technology and know-how, China's goal is to leapfrog the United States and Europe and achieve dominance in these technologies, which will have major civilian and military implications in the future. The EU does not have strong, coordinated strategies to promote the development of indigenous dual-use technologies or to protect Europe's indigenous innovation. As a result of this patchwork regime, China is either catching up to, or surpassing, European capabilities regarding most of these technologies through a 'whole-of-government' regulatory framework and financial investment, as well as by accessing European innovation and technology through a variety of means. For Europe, the incentive to keep up with China's progress in these technologies, and to protect its own innovation in this field, is one with military, but also commercial and economic, imperatives. At a time when China is increasing its commitment to this process of developing advanced, dual-use technologies, it is high time for Europe to think strategically and take action to leverage its own competitive advantages.

1. Introduction

In both the civil and military spheres, technological innovation has become a significant policy focus for the governments of the most advanced economies. The scale and scope of modern technology continues to expand. By 2020, the number of Internet of Things (IoT) devices could reach 24 billion and an estimated US$6bn 'will flow into IoT solutions including application development, device hardware, system integration, data storage, security and connectivity'.[1] The global market for robotics and systems utilising Artificial Intelligence (AI) is expected to reach US$153bn by 2020. The amount of venture capital funding going into robotics in 2015 stood at US$587 million, double the amount invested in 2011.[2]

The trend of focusing policies to take advantage of these technologies and lead in their development is evident in the European Union, as well as in China under President Xi Jinping's leadership. In an effort to drive the country towards the 2049 centenary goal of becoming a modern and prosperous socialist state, as well as building a global top-tier military capable of fighting and winning wars, Xi has turned to a two-pronged strategy for military modernisation: making large defence state-owned enterprises (SOEs) more efficient, globally competitive and innovative, while also turning increasingly to the civil and commercial sectors for innovation potential and inspiration. In particular, China is investing heavily in its pursuit and integration of emerging dual-use technologies,[3] hoping they will help the People's Liberation Army (PLA) to surpass conventional military capabilities to achieve battlefield dominance across domains. Technologies such as AI, cyber infrastructure and software, and automation are primarily civilian in their application, but their relevance to defence and to how future wars will be fought is clearly growing.

The European Union, too, has a stake in these areas, as well as economic and strategic incentives to stay ahead of the game. According to a McKinsey study, half of the activities currently carried out by workers in Europe could be automated in the near future.[4] For France, Germany, Italy, Spain and the United Kingdom, the study estimated that about US$1.9 trillion in wages and 62m workers are associated with technically automatable activities. The share of the population of working age in the EU is expected to decline until 2050, and by 2080 29.1% of the EU-28 population will be aged 65 years or over.[5] The total age-dependency ratio is expected to increase from nearly 53.9% to 80% of the EU-28 population between 2017 and 2080. In short, there will be greater demand for resources and services with fewer people in the workforce, creating an imperative for increased European investment in automation technology, which will be vital to the future workforce and to maintaining the EU's industrial and innovation edge.

Though countries like China, South Korea and the United States are particularly invested in researching the military applications of dual-use technologies, not all emerging technologies have been fully integrated into militaries yet and many are still in the development and testing phases.[6] This, however, does not take away from their potential future defence applications.

Current literature focuses largely on the relationship between China and the US, and the debate centres on how export controls and investment screening mechanisms might protect the United States' domestic innovation edge. Similar debates have been picked up in news coverage in Australia, New Zealand and the UK. However, a serious public discussion is yet to take shape about how China's quest to become a leading innovator in emerging technologies could affect the interests of the European Union and its member states.

While the US has reinforced its policing of foreign investment by bolstering the purview of the Committee on Foreign Investment in the United States (CFIUS), the European Union and its member states have been slow to come to terms with China's R&D strategies and have not yet systematically tackled the question of what they mean for related industries in the EU. Examining whether China has achieved a strategic advantage in the field of dual-use technologies, this paper will develop recommendations for the European Union to boost its own innovation potential both at the supranational and member-state level.

2. China's innovation toolbox: top-down goals and preferential conditions

In recent years, the Chinese government has pushed forward industrial reforms and laid out ambitious plans to drive domestic science and technological innovation to develop and produce high-end products and emerging technologies. At the same time, the development of China's national research and development capacities has also been utilised in civil–military integration (CMI) efforts, with commercial innovation spilling over into military applications. The military aspect of Chinese innovation is important, particularly at a time when the People's Liberation Army (PLA) is undergoing a series of major modernisation and reform efforts in its conventional military capabilities. China seeks to leverage new and innovative emerging technologies to 'leapfrog' its main strategic competitor, the United States.

The Chinese government has thus laid out a 'whole-of-government approach' to closing the gap with the West in areas such as robotics, artificial intelligence, unmanned and fully automated systems, quantum computing, space technology and hypersonic weapons. It continues to be a heavily organised, top-down process, with the government playing a vital and central role. Unlike in the US and UK, industrial plans in China are set by the Chinese Communist Party (CCP) for specific sectors at national and local government levels, with targets then set for localisation, market creation and productivity. National champions, or market leaders, are created with the help of state funding, domestic market protectionist policies, selective foreign investment, and by importing technology and talent, through mergers and acquisitions or joint ventures with Western firms. Industrial espionage also remains a tool in the Chinese innovation toolbox.[7]

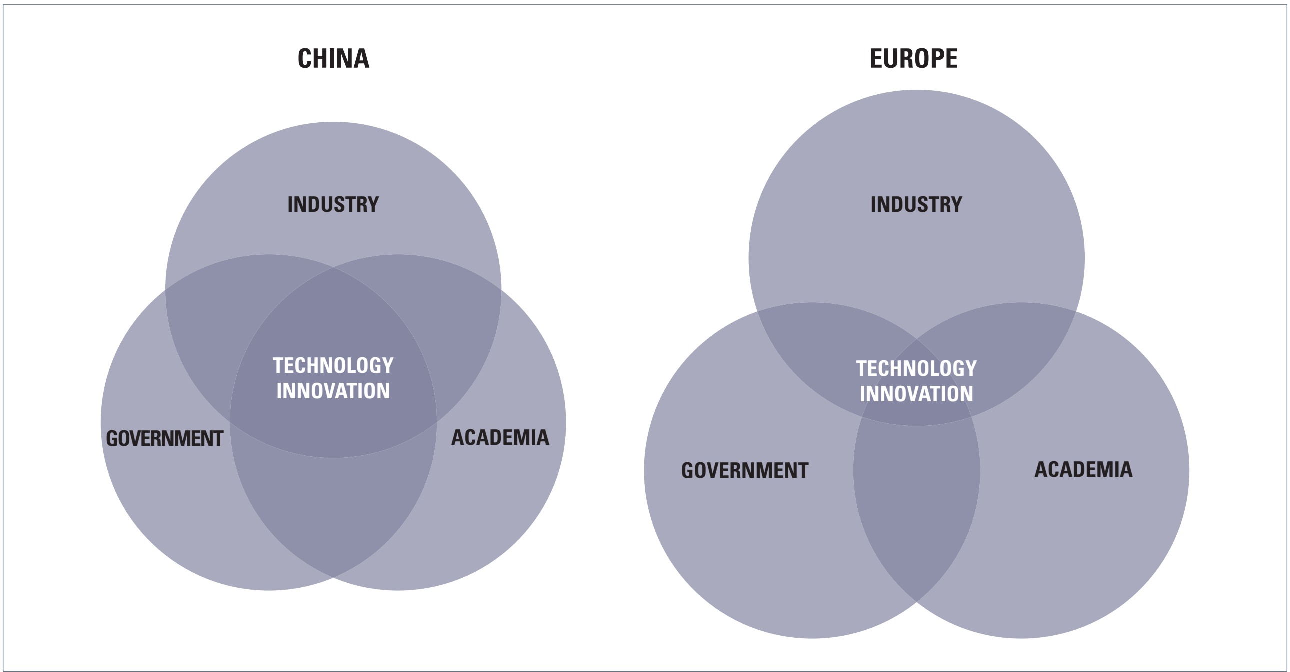
Table 2.1: China's innovation toolbox

Civil–military integration efforts
Five-Year Plans
Sector-specific industrial plans at national and local government levels
Targets for localisation, market creation and productivity per sector
Targets for international and national market shares for Chinese companies
R&D funding
Creation of centres of sector-specific innovation
Creation of national champions
Domestic market protection policies
Selective foreign investment or joint ventures with Western firms
Industrial espionage

CMI policies (named 'civil–military fusion' in China, 军民融合) have gained particular attention under Xi Jinping's leadership, during which barriers of entry for private sector companies into the defence technological industrial base (DTIB) in China have been reduced. China's defence sector currently remains heavily dominated by its state-owned enterprises (SOE), and though the proliferation of private-sector companies in China's DTIB landscape is on the upswing, bringing these two very different types of actors together remains a challenge. To this end, CCP committees have been implanted into more than 35 Chinese tech giants to make sure that the companys' objectives don't stray from those of the party.[8] In 2017, the Central Commission for Integrated Military and Civilian Development was established by the party to oversee and coordinate CMI efforts.[9] Military branches, like the PLA's Strategic Support Force (PLASSF), have signed agreements with universities and software-development companies to increase their integration outside of the military. In 2017, the deputy commander of the PLASSF, Li Shangfu, was moved to the Central Military Commission's Equipment Development Department, in what some analysts regarded as further evidence of the integration of emerging technologies into the PLA's procurement and development processes.[10]

CMI need not be focused on just integrating emerging technologies into the military. At the 2018 China International Aviation & Aerospace Exhibition, a whole exhibition hall of enterprises was dedicated to CMI, with one private company – Guangdong Hongda Blasting – showcasing its latest product, the HD-1 supersonic cruise missile with ramjet propulsion, a significant undertaking for a private-sector company

Figure 2.1: **China's top-down approach allows for greater alignment of resources to pursue technological innovation**



producing basic ordnance.[11] SOEs are also involved in this wave of cooperation – in 2017, the China Electronics Technology Group Corporation (CETC) launched the world's largest fixed-wing drone swarm using commercial fixed-wing drones produced by the private company Skywalker Technology.[12]

The 13th Five-Year Plan, presented by the Xi Jinping and Li Keqiang government at the 18th Party Congress in 2012, aimed to turn information and communications technology (ICT) into one of China's highest priorities. The Made in China 2025 and Internet Plus policies emerged, combining to push China's economy towards higher value-added manufacturing and services, through for example the use of digital technology and automation. Made in China 2025 targets ten key sectors for government support: new energy vehicles, next-generation ICT, biotechnology, new materials, aerospace, ocean engineering and high-tech ships, railway, robotics, power equipment and agricultural machinery. A few of these focus areas were previously championed in older policies, such as when new information technologies was highlighted as one of seven strategic technology in the 12th Five-Year Plan.[13] However, within next-generation ICT and robotics, the Chinese Academy of Engineering's Expert Commission for the Construction of a Manufacturing Superpower highlighted key areas of R&D focus: supercomputers, smart manufacturing products, industrial robots, robot-core components, driver-assisted (partially autonomous) vehicles, smart car technology products and advanced medical devices.[14] The Internet Plus policy 'aims to capitalize on China's huge online consumer market by building up the country's domestic mobile Internet, cloud computing, massive amounts of data (big data), and the Internet of Things sectors'.[15] Much like the Internet Plus plan, the Made in China 2025 plan has been described by the US Chamber of Commerce as aiming to 'leverage the power of the state to alter competitive dynamics in global markets in industries core to economic competitiveness'.[16]

Following large top-down industrial plans, the government also sets targets for domestic and international market shares that each local company should achieve. For example, the localisation targets for the autonomous systems industry state that by 2020, driver-assisted (partially autonomous) vehicles should make up 40% of the market, while industrial robotics should supplant foreign technology imports and make up 50% of the domestic market by 2020 and 70% by 2025.[17]

The government incentivises R&D in these priority areas and the reaching of localisation goals through the provision of national investment funds, subsidies, tax breaks, preferential loans, export subsidies and guarantees. In doing so it aims to support the development of national champion companies in each sector. Since 2014, the United States–China Economic and Security Review Commission (USCC) estimates that the Chinese central government has announced the provision of 1.7 trillion renminbi (RMB) (US$250.7bn) in state funding to support the development of strategic sectors in China and the acquisition of foreign technology and expertise.[18] Local governments provide additional support to local champions, adding another level of financial support. For example, according to the USCC, 'at least 21 cities and 5 provinces have pledged a combined US$6bn (40bn RMB) in subsidies for robotics' under the Made in China 2025 strategy. Local governments also subsidise a range of purchase prices to encourage the domestic market's uptake of these technologies. National champions, such as Baidu and Tencent, receive beneficial capital terms from state-owned banks and investment funds. In addition to these funds for specific industries and companies, R&D funding by the government aims to further push forward innovation potential. Between 2005 and 2015, total government R&D spending grew by 350%, and now does not lag far behind that of the US.[19]

China's protectionist policies play a major role in advancing its domestic industries in competitive technologies. The government's national and local procurement policies favour domestic companies in strategic sectors. Furthermore, the central government is increasingly creating China-specific standards to raise market-entry costs for foreign firms, for example in the financial technology sector and through bank-card regulations. These can be technical standards, but they also go beyond this to include cross-border data restrictions, data localisation and censorship requirements. High regulatory standards make market entry for foreign firms difficult, favouring those with local joint ventures with state-owned firms. National security, counter-terrorism and cyber-security regulations, for example, prevent foreign firms from entering the Chinese market without joint ventures in the areas of high-performance computing, cloud computing or autonomous systems. Increasingly, the government also uses foreign talent recruited through government-led programmes such as the Thousand Talents Plan and the 111 Project to bring overseas Chinese and foreign talent to China from the world's top 100 universities and research institutions. Additionally, and increasingly reported in recent years, is the central government's continued use of industrial espionage, not only against foreign companies but also within universities and other institutes of research, to gain access to cutting-edge technologies and intellectual property.[20]

The Chinese whole-of-government approach to developing national emerging technology industries has reaped some rewards. Domestic firms have been provided with the utmost government financial and regulatory support within a protectionist domestic bubble. Benefiting from international expertise and innovation, whether through legal or illegal means, Chinese industries have been catching up with their Western counterparts.

3. Mapping China's progress on critical dual-use technologies

Thanks to this approach to dual-use technology innovation by the Chinese government, the country currently leads the field in certain industries. The following sections will outline Chinese progress in key dual-use technologies, analysing the main policies and actors driving innovation in each of these sectors and recent developments, as well as cases of cooperation between Chinese and European organisations that have contributed to China's advancements, where applicable.

3.1 Space and satellites

China's space programme has been a source of concern for defence communities in the West, particularly due to the intrinsically dual-use nature of many space technologies and the close collaboration between the PLA, affiliated organisations and state-owned industry, which allows China to develop capabilities with military uses under the guise of its civil space activities. China's State Council regularly issues White Papers outlining the medium-term goals for China's space programme, but it is the China National Space Administration (CNSA) that produces the specific regulations governing it. As a result, there are multiple plans and national-level documents referring to various aspects of China's space programme, including the Beidou navigation system and satellites, among others. One of the earlier plans is the 1986 National High-Tech Research and Development Programme, also known as the 863 Programme, which was established to support technological developments needed for China's space exploration.[21] China's ambitions for dual-use space technology, however, have also been included in several more recent plans, including the 13th Five-Year Plan for Strategic Emerging Industries from 2016, which calls for China to use CMI to develop civil and military satellites.[22] China's space capabilities are one of the ten key industries included in the Made in China 2025 plan,[23] and they are also included in the 13th Five-Year Science and Technology Civil–Military Integration Special Projects Plan, issued in August 2017 by the Central Military Commission and the State Council.[24]

The PLASSF, established in 2015 as part of President Xi's military reform process, is the organisation in charge of China's space-based military assets, through its Space Systems Department. However, most of the country's space technology and capabilities are developed by institutes affiliated with the state-owned giants China Aerospace Science and Technology Corporation (CASC) and China Aerospace Science and Industry Corporation (CASIC). China's private space companies, such as OneSpace, all have ties to CASC or CASIC as well.

Thanks to the central government's support and funding, China's space programme is maturing very rapidly. Beijing is also benefiting from the programme's dual-use nature, as it is able to develop and test new counterspace weapons and systems under the pretext of developing its civil space programme. For example, China continues to regularly launch satellites and spacecraft, which allows it to perfect processes and applications that could also be used against adversaries in case of conflict. A good example is the Yaogan series of satellites. While Beijing claims that these are earth-observing satellites for civilian purposes only, the Yaogan satellites are reportedly military imaging satellites owned and operated by the PLA.[25] The Beidou navigation satellite system, China's response to the United States' GPS and Europe's Galileo systems, is rapidly expanding its coverage to Belt and Road Initiative (BRI) routes in 2018 and it aims to cover the whole world by 2020.[26] Doing so will allow Beijing to develop real-time global surveillance and warning systems capabilities.

Furthermore, China is developing counterspace capabilities to target adversaries' space-based assets in case of conflict. These include directed-energy weapons to blind or damage space-based optical sensors, which are often used for missile defence and remote sensing, as well as satellite jammers and co-orbital kinetic kill capabilities. China first tested anti-satellite (ASAT) weapons in 2005 and has made substantial progress since.

WHAT TO WATCH FOR:
Weaponisation of outer space and the provision of alternative infrastructure

- Will China test another, more advanced anti-satellite weapon within the next five years?
- When will China's Beidou system cover the whole world? Will it replace GPS in countries involved in the Belt and Road Initiative?

In 2007, for instance, China tested a weapon that successfully destroyed one of its own satellites.[27] And in June 2016, in another example of the dual-use nature of its space programme, China launched its Aolong-1 spacecraft, which is supposedly tasked with cleaning space junk with its robotic arm. This spacecraft, however, is also suspected of being a dual-use ASAT weapon able to interfere with adversaries' satellites and other space-based assets.[28]

The CNSA has cooperated closely and regularly with the European Space Agency on various projects, as well as with the space agencies of some individual member states. The best example is China's close involvement in the EU's Galileo programme. In 2003, China became a partner in Galileo, contributing €200m (US$228m at the time) to the project. And while the EU eventually barred China from participating in Galileo in 2007,[29] by then China had gained access to information about the project, some of which was dual-use in nature and reportedly integrated into China's own Beidou system.[30]

3.2 Cyber

As President Xi stated during the April 2018 Cybersecurity and Informatization Work Conference, cyber security is the area within CMI with the most 'dynamism and potential'.[31] Cyber capabilities are a priority for the Chinese government and an integral part of military modernisation and informatisation efforts. The 2017 Cybersecurity Law is the main policy governing cyberspace in China. This law promotes the development of indigenous technologies and restricts sales of foreign ICT, while also mandating that foreign companies operating in China store data in China and submit to government-run reviews.[32] The International Cyberspace Cooperation Strategy, released in March 2017, brings the dual-use nature of cyber capabilities to attention, highlighting the PLA's important role in defending China's sovereignty in cyberspace and calling for the development of a military 'cyber force'.[33] Cyber is discussed extensively in China's Made in China 2025 strategy and the 13th Five-Year Plan – both in the Plan for Military–Civilian Fusion S&T Developmental Guide and the Science and Technology Civil–Military Integration Special Projects Plan. The latter highlights national cyberspace security as a project to be completed in 2030 to the benefit of both the Chinese economy and military.[34]

Organisationally, the PLASSF is in charge of the PLA's cyber capabilities, while the Cyberspace Administration of China (CAC) governs China's civilian cyber capabilities and developments. China's corporate cyber-espionage units and capabilities, however, seem to have been recently transferred from the PLASSF to the Ministry of State Security (MSS).

In December 2017, China unveiled the country's first civil–military cyber security innovation centre in Mianyang, Sichuan province, which was set up by China's largest cyber security company, 360 Enterprise Security Group. Under the authority of the Central Commission for Integrated Military and Civilian Development, it will focus on building cyber-defence systems for military uses.[35]

As a result of this level of attention and support from the central government, Chinese capabilities in this area have improved. However, the attribution problem when it comes to cyber intrusions and attacks, along with the opacity of cyberspace, mean that the extent of China's progress is unclear. Chinese writings suggest that the country believes its cyber capabilities are still inferior to those of the US, especially when it comes to cyber defence, so it is working to train more personnel and supporting domestic innovation to overcome these problems.[36]

Despite this, a series of recent intrusions into government networks and private firms' servers signal that Chinese operators – whether governmental or private – have substantial capabilities to penetrate networks and steal information. This has been a common method used by Chinese actors to acquire foreign military and dual-use technologies. In 2017, for example,

WHAT TO WATCH FOR:
Normalisation of Chinese cyber norms or continued opacity of Chinese cyber actors

- Will China fully implement its 2017 Cybersecurity Law and force foreign companies to store their data in China if they want to do business in the country?
- Will China be more transparent in how cyber defence and security responsibilities are split between the PLA's Strategic Support Force and non-military bodies like the Ministry of State Security?

it was revealed that data about Australia's F-35 stealth fighter and P-8 surveillance aircraft programmes may have been stolen when a defence subcontractor was hacked with a tool often used by Chinese hackers.[37] Cyber-security firm Cylance also claimed to have found a trojan with links to a Chinese hacking group in a Western aerospace company.[38] In November 2017, the US charged three Chinese nationals affiliated with Chinese cyber security company Guangzhou Bo Yu Information Technology with hacking into Siemens, Trimble Inc and Moody's between 2011 and 2017 to steal information.[39] This company is reportedly affiliated with PLA Unit 61398.[40] Only a few months later, in June 2018, US officials reported that Chinese hackers had compromised a US Navy contractor's system earlier in the year and stolen sensitive information on undersea warfare, including plans for a supersonic anti-ship missile to be used by the navy.[41] These examples, along with the many other instances that have been revealed in recent months, show that China's cyber capabilities, especially when it comes to stealing information, have progressed very rapidly.

3.3 Quantum technology

China is working to become a world leader in quantum technologies by 2035, including quantum computing, radars and cryptography.[42] Research into dual-use quantum technology has long been supported by various policy plans and strategies, starting with the 863 Programme and the 1997 National Basic Research and Development Programme, or 973 Programme,[43] which were meant to support research into dual-use advanced technologies, including quantum. More recently, the Made in China 2025 plan also called for advances in quantum computing, and marked the start of growing interest and levels of funding for these technologies. Since then, a number of national-level plans have called for further research into quantum technologies. The most important of these are the National Key Research and Development Plan from March 2016, the 13th Five-Year National S&T Innovation Plan and the 13th Five-Year National Strategic Emerging Industries Development Plan, both of them also from 2016. Quantum is also recognised as a key component of China's civil–military integration strategy, as quantum technologies have extensive military uses. As such, the 13th Five-Year Science and Technology Civil–Military Integration Special Projects Plan includes quantum communications and computing among its prioritised projects.[44]

All of these plans reveal a high degree of support from Beijing for advances in quantum technology, as do the levels of funding dedicated to them. While the total level of funding available for research into quantum technologies is unknown, some studies suggest that it can reach hundreds of millions of dollars.[45]

China has also established a number of institutions to pursue this goal. At the national level, the Chinese Academy of Sciences (CAS) established the Quantum Information and Quantum Science and Technology Innovation Research Institute in the summer of 2017,[46] and Beijing is also building the National Laboratory for Quantum Information Science, which is expected to be completed by 2020.[47] China's defence industry is also getting involved in this process, following the national strategy of civil–military integration. China's University of Science and Technology, for example, has set up joint laboratories and development centres dedicated to quantum research with the Aviation Industry Corporation of China (AVIC) and the China Shipbuilding Industry Corporation (CSIC).[48] Both the Academy of Military Science (AMS) and the National University of Defense Technology (NUDT) – which are PLA organisations – have also stepped up their quantum research efforts. The PLASSF, is also likely to be involved in the research efforts, although verifiable

WHAT TO WATCH FOR:
Discovering the actual potential of quantum technologies in civilian and military applications

- When will China's quantum communications network become fully operational? Will it ever be expanded nationwide?
- Will China manage to develop and operationalise a quantum radar capable of detecting stealth aircraft before the United States does?

information on its involvement is sparse. The expertise of China's tech giants is also being leveraged – companies like Baidu and Alibaba have set up joint research centres and projects with CAS and other government-linked institutions to research quantum technologies.

Fully operationalised quantum-based military systems are still some way away. China's efforts, however, are starting to pay off. Beijing, for example, has already set up a quantum communications network which extends from Beijing to Shanghai, and it plans to expand this network nationwide.[49] While this network is still not fully operational, once finalised it could help secure China's military and government communications with quantum cryptography. Additionally, China was the first country to successfully launch a quantum satellite into space in August 2016, which may help Beijing create a global quantum communications network.[50] China is reportedly investing heavily into quantum radar, imaging and navigation technologies, which could have major military uses, particularly as a way to enhance intelligence, surveillance and reconnaissance (ISR) capabilities, reduce the PLA's dependence on the space-based Beidou satellite system and potentially offset adversaries' stealth technology. While these are important advances, China's progress should not be overstated as the actual use of quantum technologies in military operations has not yet materialised. It thus remains unclear whether most of these technologies will ever have the impact on the future of warfare that is currently assumed.

Some European companies and governments have also played a role in helping China advance towards its quantum ambitions. The quantum satellite China launched in 2016, for example, was the result of a cooperation project between Chinese and Austrian researchers. The idea to launch a quantum satellite was first proposed to the European Space Agency by Austrian physicist Anton Zeilinger. He, however, failed to secure funding and support from the ESA. According to Zeilinger, '[the ESA's] mechanisms are so slow that no decision was made'. As a result, Zeilinger's team turned to China, where they cooperated with a team led by Pan Jianwei of the Chinese Academy of Sciences, whose PhD Zeilinger once supervised, to launch the world's first quantum satellite.[51] Additionally, some reports suggest that the Sino-British Joint Space Science and Technology Laboratory may also be working on quantum sensing.[52]

3.4 Artificial Intelligence

China aims to have overtaken the West in AI by 2025 and to be a global leader in the area by 2030, with an AI and AI-related industry worth 11 trillion RMB (US$1.6 trillion).[53] Beijing hopes, as part of the Made in China 2025 programme and through the use of AI, to move China away from a manufacturing-based economy and towards one based on innovation and high-quality, high-tech products.

In July 2017, China's State Council published the Next Generation Artificial Intelligence Development Plan. In December 2017, the Ministry of Industry and Information Technology (MIIT) published the more specific Three-Year Action Plan for Promoting the Development of a New Generation Artificial Intelligence Industry (2018–2020). The action plan focuses on the in-depth integration of information technology and manufacturing technology to turn China into a manufacturing and cyber superpower. It puts forward four major tasks to develop a wide range of AI-dependent technologies.[54] The Ministry of Science and Technology has also issued a call for tenders for 13 transformative technology projects to be realised by 2021, with the support of state funds. The government has promoted innovation clusters and research hubs, like the AI industrial park in Beijing; AI talent training programmes, like that launched by the Ministry of Education in April 2018; and the 'AI national team' – all practical examples of the implementation of the MIIT action plan.[55]

China is already well-placed to reach its AI goals. Chinese companies accounted for 48% of the world's total AI start-up funding in 2017, and China's AI industry attracted 60% of global funding for AI between 2013 and 2018. Furthermore, Chinese technology giants such as Alibaba, Tencent and Baidu already use AI in a wide range of services.[56] The easy accumulation of and access to national (and to some extent international) data means that Chinese R&D centres and companies have a goldmine of resources to continue to develop their technologies. To illustrate China's comparative advantage in data collection: in 2018, China had 1.4bn mobile phone users, while the US only had 427m.[57]

The Chinese government is eager to promote international collaboration in AI,[58] and wants to set the norms around its use. Beijing responded to recent concerns in China over data protection[59] by issuing the 2017 Cybersecurity Law, but the law focuses mostly on regulating the activities of companies and not those of the government. For example, the government's integration of AI technologies into facial-recognition programmes for increased surveillance power points to the overwhelming authority the CCP invokes in the name of national security.[60]

In the realm of defence, too, AI plays a current and future role. Beijing aims to build high-technology weaponry that would enable China to leapfrog the United States' currently superior military capabilities, integrating advanced technologies like AI and big data into the PLA. AI will be incorporated into Chinese military technologies across domains, from unmanned combat aerial vehicles (UCAVs) and drone swarms to fire-and-forget modes for China's varied missile arsenal and cyberattacks. Importantly, the PLA aims to use AI to support intelligent operations and system-of-systems warfare.[61] According to Shen Shoulin and Zhang Guoning, '"brain supremacy" (the ability to interfere with or damage the cognition of the enemy) will replace earlier warfare concepts seeking military dominance over land, sea, air and more recently space and cyber domains'.[62] Once intelligence supremacy is achieved over enemies in the information space, supremacy over other domains is rendered meaningless, according to this approach.[63] AI will also be imperative to intelligent monitoring and early-warning systems.[64]

3.5 Automated systems

Closely linked to China's plans to become a global leader in AI is its aim to become a global leader in automated systems. In the civilian sector, the 13th Five-Year Plan for Economic and Social Development of the People's Republic of China ordered the country to press ahead with vehicle automation,[65] and the Ministry of Industry and Information Technology (MIIT) and China's Society of Automotive Engineers published the 'Technology Road Map for Energy Saving and New Energy Vehicles' in 2018. According to the plan, partially autonomous (driver-assisted) cars will account for 50% of China's sales by 2020 and highly autonomous cars will represent 15% of sales by 2025. By 2030, fully autonomous vehicles are expected to account for 10% of sales.[66]

The drive for automated systems is supported largely by the same policies and programmes as the government has set for AI. This is largely due to the dependence of autonomous systems on AI and big data. For example, within the Ministry of Science and Technology's AI national team, Baidu has been tasked with building and leading an open platform on autonomous driving, intended for small and medium-sized enterprises (SMEs) and start-ups to benefit from.[67] Baidu is also working to deliver a commercial autonomous car in China before the end of 2018.[68] In anticipation of

WHAT TO WATCH FOR:
The ability to collect, store and utilise data for Artificial Intelligence applications in defence

- Will China being able to apply AI to its system-of-systems warfare, notably to protect its interests in Taiwan or the South China Sea by making it difficult for the US or other actors to operate there?
- Will we see attempts by China to utilise its expanding telecommunications network through the Belt and Road Initiative to collect even greater amounts of data?
- Will we see expanded and improved data-storage capabilities in China to cater for its big-data collection needs?

reaching the government's 2020 targets for partially or fully autonomous vehicles, the MIIT is drafting a bill to regulate autonomous driving, to be followed by provincial and city-level policies.[69] In conjunction with private-sector companies that lead in the development of these technologies, the Beijing Municipal Commission of Transport has also announced exclusive autonomous-vehicle testing zones in Beijing, as well as in other local city governments.[70]

China's autonomous vehicles and autonomous logistics vehicles using advanced driver-assistance systems (ADAS) will be worth 200bn RMB (US$28.9bn) by 2020.[71] ADAS has direct and relevant applications to the PLA as it is the first step towards building fully autonomously-driven vehicles. China's unmanned aerial vehicle (UAV) industry has developed apace over the past few years, expanding both in the civilian and military spheres. Though Chinese UAV programmes started in the 1980s, the first commercial drone company only entered the Chinese market in 2007. China accounts for 70% of commercial drone manufacturing and more than 70 countries have acquired Chinese drones of varying classes and types. China overtook the US in the filing of drone patents by 2012, and by 2017 it had the highest number of filings by any country in the world. The civilian industry focuses on the expanding hobby drone market, as well as commercial uses for drones in agriculture, urban planning, logistics and even disaster relief.[72]

The PLA has started using UAVs for reconnaissance and surveillance as well as in preparation of armed operations, though not yet directly in armed combat. Chinese variants of US MQ-1 *Predator* drones have, over the past ten years, played increasingly crucial roles in advanced monitoring and targeting capabilities, with the latest variants of Chinese drones capable of flying longer ranges, at higher speeds and carrying heavier payloads than their previous versions. Though the development of Chinese variants of US armed and surveillance drones was the result of corporate espionage and theft, and not the direct result of government policies that promoted indigenous innovation, the acquisition of these technologies has nevertheless added to China's command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) and integrated precision strike capabilities.[73] In China, over 30 military and government agencies have used drones to survey Chinese citizens in at least five provinces.

China has also become a leading exporter of heavy and armed UAVs, supplying countries that are either prohibited from purchasing or cannot afford to purchase US equivalents. Between 2008 and 2017, China sold 68 strike-capable UAVs, compared to only 62 sales of US *Reaper* and *Predator* drones and 56 Israeli *Hermes* or *Heron* TP drones. The largest proportion of Chinese drone sales seems to consist of earlier variants, with the CH-3 making up 44% of total sales and the Wing Loong 1 making up 18% of sales.[74] The sales of Chinese heavy and armed UAVs to countries that use them in combat, such as Nigeria, allow China to gain valuable combat experience in integrating UAVs into conventional strike capabilities.

Aside from UAVs, China has in 2018 started testing remotely operated main battle tanks using obsolete legacy platforms and logistics vehicles, and it also continues to research unmanned underwater vehicles (UUVs).[75] Intelligent systems like UUVs are inexpensive compared to their conventional manned counterparts.[76] The PLA aims to use these new capabilities as a temporary workaround for the low levels of combat readiness of PLA personnel. However, when issues of combat readiness are addressed in the future through training, professionalisation and exercises, these intelligent systems might still not be rendered entirely obsolete, and they may supplement the capability mix of the PLA of the future, one with both manned and uninhabited platforms.

WHAT TO WATCH FOR:
Autonomous vehicles providing PLA with logistics and capabilities across large distances

- Will China start to deploy autonomous vehicles in its national military training exercises, like *Stride* in Zhurihe, for example in military logistics?
- Will China start to employ UUVs to enhance its ability to protect its maritime sovereignty claims over the East and South China seas?

3.6. Robotics

The Made in China 2025 plan lists the robotics industry, in addition to AI and automation, as one of the priority sectors to transform and upgrade China's manufacturing industry. The government aims to raise the global market share of Chinese-made robots to over 50% by 2020, a 19% increase from 2016. The Robotics Industry Development Plan for 2016–2020 aims to promote the use of robotics in a broad range of industries and to attract foreign investment. In addition to the Made in China 2025 plan, the Development Plan aims to make 100,000 industrial robots using domestic technology yearly by 2020. The CCP also supports companies that implement robotics-enabled automation in key industries, such as manufacturing and logistics. For example, in 2018 the State Council announced it would cut more than 60bn RMB (US$8.78bn) worth of taxes for small and micro-enterprises and high-tech firms in order to reduce operating costs for small companies and stimulate innovation.[77] This builds on the 2008 Enterprise Income Tax Law, which introduced tax incentives for new high-tech enterprises.[78] As with AI, the MIIT has also approved a plan to build a national robotics centre that will 'focus on tackling common bottlenecks such as human-machine interaction technologies and compliant control'.[79]

These efforts seem to be producing results. According to some estimations, by March 2017, more than 800 companies in China were directly involved in robot manufacturing, and by the end of 2017, there were over 6,500 companies.[80] The Yangtze River Delta (Shanghai, Kunshan, Changzhou, Xuzhou and Nanjing) as well as the Pearl River Delta (Shenzhen) are the main regions of robotics innovation and development. China also has 40 robotics-focused industrial parks throughout the country, which benefit from government resources.

China's specialised robot market includes robots used for military purposes or search and rescue operations. Such robots can, for example, serve as exoskeletons, carry heavy equipment or carry out tasks for soldiers at a distance.[81] In 2017, China's market for specialised service robots was estimated at US$740m and it is expected to rise to US$1.24bn by 2020.[82]

Though drones can be classified within robotics as unmanned automated systems, not all robots are drones. For example, AnBot, a security robot developed by China's National Defense University, has sensors similar to human eyes and ears. It can patrol autonomously and can shock people with electricity or take photos using facial recognition.[83]

The introduction of robotics to the battlefield will ultimately allow the PLA to specialise in high-end warfare, cutting unnecessary tasks currently performed by human soldiers. Robotic systems that increase capability at reduced costs will increase battlefield density, as many can be deployed at once. The connectivity between many different robotics units will be key in this scenario, in order to decrease the risk of their individual vulnerability. Using AI to develop robotics will be vital for these systems to think independently, driven by actions on the battlefield and by their ability to adapt faster than humans could.[84]

China has already purchased some European robotics companies. The most famous case, and indeed one that led some EU member states to call for an investment screening mechanism, was the 2016 takeover of Germany's most famous robotics company, Kuka, by Chinese appliance manufacturer Midea.[85]

WHAT TO WATCH FOR:
Autonomous vehicles providing PLA robotics as replacements for PLA soldiers, across the military or in specialised tasks

- Will we see PLA soldiers being replaced, not just for logistics tasks, but in fighting capacities, by robotic systems?
- Will there be a focus on testing robotics that carry out counter-terrorism tasks such as explosive detonation or surveillance on behalf of cooperative training efforts between the PLA and local troops, for example in Afghanistan?

4. Implications for Europe

The EU, unlike China and the US, does not have strong coordinated strategies to promote the development of indigenous dual-use technologies or to protect Europe's DTIB and indigenous research. While some policies and strategies do exist, they are often uncoordinated between the EU and its various member states and among member states, and may even be occasionally contradictory.

As a result of this patchwork regime to both promote and protect European technologies, China is either catching up to, or surpassing, European capabilities regarding most of the technologies discussed above, from quantum and cyber to autonomous systems and AI. In terms of unmanned systems, for example, China has managed to develop a very strong UAV industry that has occupied the lower end of the international market, while the US still occupies the higher end and Europe buys American. Furthermore, the Beidou satellite navigation system will very soon surpass the European Union's Galileo system in terms of coverage and functionality, and Chinese advancements in quantum computing seem to be unmatched worldwide.

This section will look into existing European policies to both promote and protect indigenous innovation in dual-use technologies and will then move on to a discussion of the various ways that China accesses European technologies and know-how, and how this all affects European interests.

4.1 Existing European policies

Several existing documents at the EU-level, such as the EU's Digital Single Market Strategy, the AI for Europe Communication or the 2013 Cybersecurity Strategy, discuss Europe's ambitions to become a leader in certain sectors, such as AI and cyber defence. Most of these policies, however, are relatively vague. Furthermore, implementation is left to member states, which means that application of the policies varies widely between countries. This is partly due to the fact that many of these dual-use technologies are seen as strategic, so European member states are reluctant to allow EU institutions to regulate on their behalf, instead preferring to maintain control over these areas.

Due to this lack of coordination on policies to promote dual-use technologies at the EU-level, the various technologies discussed above have received varying levels of support and attention by the EU and its member states. Technologies that have been deemed critical or strategic, often because of their potential to become drivers of future economic growth, are covered by and discussed in several policies and strategies, both at the EU-level and at member state-level. The rest of the technologies, however, have been largely ignored by policymakers.

AI, for example, is one of the technologies that has received most attention in Europe. Besides the European Commission's AI for Europe communication, in January 2018 France also launched its AI strategy – the country's top priority is to foster a fullyrounded French industrial sector and to develop a French AI model that is respectful of privacy.[86] When compared to China's very concrete AI strategy, this French policy is generally aspirational and mostly sets out vague goals. Most member states do not have concrete national strategies regarding AI, but proposals to boost the AI sector are included in many national digital strategies, including the UK's.

The EU does, however, have a Strategy on Key Enabling Technologies (KETs) to promote the development of technologies[87] that have a wide range of applications and provide the basis for innovation in various industries. This strategy aims to align the efforts of EU institutions and member states in order to make better use of public resources to support the development of KETs. It does not, however, propose an increase in public spending for this purpose.[88] This policy could, presumably, also contribute to the development of critical dual-use technologies in Europe.

In terms of protecting indigenous European research and technologies, Europe also lacks strong, coordinated

Map 4.1: **Transfer of EU technological innovation to China despite selected member states' investment screening mechanisms**

regulations. While dual-use and arms exports are covered by various international and European Union laws and regulations, they are interpreted and implemented by national governments, resulting in varying degrees of strictness and compliance. Besides, only 12 EU member states have investment screening mechanisms, and they range widely in terms of the type and range of thresholds to trigger screening and the definition of what is considered sensitive or dual-use technology. The EU is now finalising a new EU-wide mechanism, in order to respond to the 77% increase in Chinese investment in the EU from 2015–2017 and the growing concern among certain member states, especially Germany and France, which triggered this process along with Italy.[89] This mechanism, however, will mostly be a framework for information sharing between member states and the EU Commission, with member states retaining the last word.[90] Furthermore, in many member states, industrial and economic policy considerations often influence export and investment decisions. Therefore, in countries that are more export-dependent or more dependent on trade with China in general, there are vested interests in keeping exports and investment as open as possible, which may limit the power of the new screening mechanism and of the EU's export controls.

4.2 How China accesses European technologies

Europe has become a major target of China's push to acquire advanced foreign technologies and key components to support its own development of dual-use technologies. This is partly due to the fact that the EU still has a competitive advantage versus Chinese firms when it comes to engineering and the production of high-tech systems and components, especially in some sectors such as robotics and cyber security. China has therefore come to see Europe as something akin to a 'technology piggybank'. Beijing uses various methods to get access to European technologies that it needs for its own development, including investments into European companies, cooperation agreements with European organisations, cyber espionage, the acquisition of European talent and joint ventures with European firms wishing to operate in China, among others.

Investments and acquisitions

Chinese firms, often directed by the government, have been trying to acquire high-tech European companies in order to fill China's gaps in its technology R&D process. And while the EU and member-state governments are adopting a tougher stance on these investments and coming up with a new investment screening mechanism, as discussed above, the difficulties in enforcing these regulations across the EU, as well as the difficulties in defining dual-use and sensitive technology, mean that the impact of these new systems is going to be limited, at least in the short term. For now, albeit with more constraints and limitations, China will most likely still be able to purchase companies that produce high-tech specialised tools or systems that, in turn, help China advance faster in its goals to develop dual-use technologies.

Examples of the acquisition of European companies for technology transfer purposes abound. The 2008 purchase of UK-based Dynex Semiconductor by Chinese railway firm Zhouzhou CRRC Times Electric, for example, allowed China to access the company's high-powered semiconductors, which were reportedly fundamental for the development of electromagnetic catapults for the PLA Navy's new aircraft carrier.[91] In 2016, Chinese white-goods producer Midea acquired German high-tech robotics manufacturer Kuka. Now under Chinese ownership, the company's German automotive partners have reportedly expressed concerns about keeping research centres in China due to the country's strict cyber security laws and growing state influence on foreign companies.[92] This deal caused substantial concern within the German government and led Berlin to strengthen Germany's foreign investment and takeover rules, allowing it to block, on security grounds, further attempts by Chinese companies to get their hands on advanced German technology. In August 2018, for example the German government blocked Yantai Taihai Group on national security grounds from purchasing Leifeld Metal Spinning, which makes machines used to produce high-specification metals for the aerospace industry, among other uses.[93]

Cyber espionage

Cyber intrusions into large European companies are commonplace, if not as widespread as in the United

States. The hack into Siemens revealed in the US indictment of three Chinese nationals in 2017, for instance, was rumoured to have originated in China's interest in the company's research into guidance and navigation. A recent piece by Politico suggests that the European Commission is preparing to confront China on the alarming levels of cyber espionage within the EU. The piece, which cites a study by PricewaterhouseCoopers (PwC) and DG GROW (the European Union's internal market and industry department), mentions that cyber espionage – generally, not exclusively by China – is estimated to cost Europe up to €60bn EUR (US$68.1bn) in economic growth and 289,000 jobs in 2018.[94]

New Chinese legislation, including the 2017 Cybersecurity Law, also requires that foreign companies operating in China store their data on Chinese servers and submit to government inspections, which brings with it concerns regarding the privacy of intellectual property and trade secrets. Similar rules apply to foreign companies that set up joint ventures with Chinese partners to operate in China, or those that are not registered in China but do business in the country.

Beijing is also pushing to set international digital standards on several areas, such as 5G, and is encouraging its international technology giants, such as Huawei and ZTE, to build up their business overseas (especially in Europe). Huawei, for instance, is bidding to build Germany's 5G infrastructure,[95] which has sparked fears that back doors may be installed into their equipment in order to allow for Beijing to access data. These fears stem from China's 2017 National Intelligence Law, which states that Chinese 'organisations and citizens shall, in accordance with the law, support, cooperate with, and collaborate in national intelligence work'.[96]

R&D collaboration and talent acquisition

European companies and organisations have also – sometimes unwittingly – entered cooperation agreements with Chinese counterparts which have produced systems that have then been used by the PLA. A clear case is the cooperation between the Chinese and the Austrian Academy of Sciences, which culminated in China's 2016 quantum satellite launch. Another relevant case is China's initial involvement in the Galileo project, as well as the CNSA's ties to the European Space Agency and several other member-state space agencies.

Beijing is simultaneously attempting to attract top European talent to China, providing individuals with high levels of funding and support to carry out their research into dual-use technologies. If this process continues, Europe will suffer from a 'brain drain' that could prevent it from engaging in the high-tech research that is necessary to protect its own interests.

Exports to China

Despite export controls, sensitive and dual-use components originating from Europe have found their way into Chinese security and defence-related technologies. Manufactured goods, machinery and transport equipment and miscellaneous manufactured articles account for a large proportion of the European Union's exports to China.[97] The EU has attempted to restrict export of weapons and dual-use technologies to China through the 1998 EU Code of Conduct on Arms and the 2009 European Communities regime for export controls of dual-use items.[98] However, these regulations are far from perfect. Both instruments are open to interpretation by member state national governments. The Code of Conduct, for example, predates the Maastricht Treaty and is thus a political decision and not an actual law, and the EC regulation is classified as a hybrid regulatory system, whereby national authorities have the final word. Furthermore, while Article 4 of the EC regulation requires a licence for every dual-use export if the EU has implemented an arms embargo against the recipient country, this does not apply to China as the 1998 Code is a political decision and not an EU common position or joint action. In the EC regulation's Annex I, a list of dual-use technologies is meant to illustrate which technologies are considered dual-use and thus fall within the export control regulation. However, this list is not up to date, and cannot keep up with the fast-paced development of dual-use technologies. Lastly, the EU does not have clear oversight over member states' dual-use exports, as member states only report denials of licenses, rather than the volume and type of licenses that have been granted.

This has meant that some dual-use technologies have been exported to China. In 2018, the Netherlands' government blocked Dutch companies from continuing to export dual-use components that could be used in Chinese surveillance cameras and therefore indirectly contribute to China's Skynet surveillance programme.[99] In other instances, China has imported software used to design fighter jets and civil-purchase helicopter engines to shift into military helicopters.[100] For example, in 2012 the Canadian branch of Pratt & Whitney pleaded guilty to two federal criminal charges in the United States for violating a US export control law and making false statements. According to the federal prosecutors Pratt & Whitney Canada exported modified software to China to test its new military helicopter (Z-10) that used legally exported commercial engines.[101] European engines, too, have made their way into PLA platforms. For example, German MTU Friedrichshafen's civilian marine diesel engines are built under license in China, but have played a key role in China's naval build up as they are reportedly used in PLA Navy *Song*-class attack submarines. Similarly, the PLA's Jiangkai I and II frigates are powered by engines from S.E.M.T. Pielstick, a French subsidiary of the German supplier MAN Diesel & Turbo.[102]

Using all of these methods, China has managed to access critical European know-how and technologies. And these technology transfers, whether voluntarily or involuntarily, have aided China's development of dual-use technologies, some of which are currently being used or may be used in the future by the PLA.

This issue does not only affect Europe and, as such, it has become an increasingly important point of contention between other Western industries and governments and China. In October 2018, US Vice President Mike Pence stated that 'through the Made in China 2025 plan, the Communist Party has set its sights on controlling 90% of the world's most advanced industries' and that to do so, 'Beijing has directed its bureaucrats and businesses to obtain American intellectual property […] by any means necessary'. This includes foreign technology transfer policies for foreign firms wishing to operate in China, mergers and acquisitions, and the 'wholesale theft of American technology' through cyber espionage.[103]

The US is far from alone in its criticism of China's unfair and, in some cases illegal, practices. The Australian government is currently grappling with increasing concern over Chinese investments in sensitive Australian industries, as well as with the growing academic ties between China and Australia. Bilateral research and development collaborations on sensitive technologies are defended by Australian research and academic communities, though currently criticised by the government and security agencies. The latter point to universities breaking export controls on technology that could be used for military purposes, as well as reports in 2017 that hundreds of research projects linked Australian scientists with senior Chinese military figures and PLA-backed PhD students studying in Australia.[104] Australian industry argues that restricting export licenses is bad for their business, with China as their main international market.[105] Nevertheless, with stories such as that of the Australian National University hack becoming public, the government has called current lax approaches to protecting domestic innovation 'naïve'.[106]

While China's advances in these dual-use technologies will have a limited impact on Europe in the short term, in the medium to long term, at least some of these technologies are likely to have a significant impact on the future of warfare, as well as economic processes and trade relations. If China were to achieve dominance in these areas, the global strategic balance would change quite substantially. Ultimately, this is an issue that should be of central concern to European policymakers and industry leaders.

5. Conclusions and recommendations

In its quest to become a global 'science and tech superpower' (科技强国) and to build a strong military that can fight and win wars, China has embarked on a major process to achieve civil–military integration and develop advanced dual-use technologies. China's goal is to leapfrog the United States and Europe and achieve dominance in these technologies, which will have major civilian and military implications in the future.

China has a clear advantage in this process to achieve technological dominance. The one-party system allows Beijing to adopt a whole-of-government approach to close the technological gap with the West in areas like AI, quantum technology, unmanned systems, robotics, cyber and space. Following a heavily organised, top-down process, China has been able to mobilise government, industry and society to pursue this goal, something that has proven difficult to do in Europe or the United States. While in China all major industries and technology companies have been quick to embrace the government's strategy of civil–military integration, in the West governments have encountered more resistance. In the United States, for example, Google pulled out of the Department of Defense's Project Maven (which uses AI to interpret videos and images) due to employee and public concerns over the potential military uses of this technology.[107]

The Chinese authorities have set plans and targets for industry, they incentivise domestic innovation through tax breaks, subsidies and other means, and they have also put in place protectionist policies to advance China's domestic industries and national champions. Simultaneously, Beijing has reaped benefits from Chinese companies' links to foreign companies and research centres, promoting technology transfers that aid China's pursuit of dominance in these dual-use technologies. As a result, China has made remarkable progress. Chinese industries are catching up to their Western counterparts and in certain areas they even lead the field.

Some of these dual-use technologies may not be operationalised in a military context in the short to medium term, either because their applications are unclear or because the technologies are too expensive or simply not developed enough to be rolled out widely. However, the inherently dual-use nature of all of these technologies means that, even if they turn out to be of little use for military purposes, they will have other civilian uses that will have a much broader impact on China, on Europe–China relations and on the global balance of power. China's rapid advances, therefore, should be of concern to policymakers and industry in the European Union.

This, however, is neither a technological race nor a zero-sum game. China's progress should not prevent the European Union and its member states from investing in the development of their own dual-use technologies, nor should it lead to Europe trying to replicate China's approach to R&D and CMI. Instead, European states should leverage their own competitive advantages, and the EU should protect what it identifies as critical to member states' future war-fighting capabilities and wider European security. Europe has, among other things, a highly-educated talent pool, an innovative private sector, a competitive edge when it comes to engineering and the production of high-tech components, as well as available funding and a number of pre-existing initiatives to promote innovation. Furthermore, coordinated European technology and industry initiatives, such as Airbus or the European Space Agency and its Galileo project, have been successful in the past and can serve as best practices for future European initiatives to develop advanced, dual-use technologies. Some initiatives that aim to fill this gap are already emerging, such as the Joint European Disruptive Initiative (JEDI), modelled on the United States' Defense Advanced Research Projects Agency (DARPA). This non-governmental group, however, is still in its early stages and trying to get support from as many European member states as possible.[108]

Where strategic, security or defence interests are not at risk, the European talent pool should seek opportunities to cooperate with China. Leveraging both China's and the EU's resources, talent pools and R&D infrastructure could ultimately assist the EU, its member states and China in finding solutions to common problems related to climate change, space exploration and combating old age in the work force. In the end, political will, vision and investment will determine whether the EU is able to identify what the strategic no-go areas of collaborative innovation with China are, and how it maintains its innovation edge in these sectors.

For Europe, the incentive to keep up with China is therefore one with military, but also commercial and economic, imperatives. And at a time when China is increasing its commitment to this process of developing advanced, dual-use technologies, it is high time for Europe to think strategically and take action. As a response to China's advances, the EU and its member states should pursue the following actions.

5.1 Protecting European industry and dual-use technology innovation

■ Set up a stronger investment screening mechanism at the EU level

The European Union's proposal for a mechanism to screen foreign investment in strategic sectors is a good start but should be expanded upon. The current proposal's non-binding nature remains deeply problematic, as member states are free to disregard EU Commission findings and recommendations. Should an EU-wide agreement be too challenging for the moment, a group of like-minded member states could aim at coordinating their national screening mechanisms in order to create stricter conditions for foreign investment in critical sectors and technologies in these countries. This arrangement could then be gradually expanded to include as many EU member states as possible. To incentivise participation, the initiative could also be linked to EU funding for research and development projects in dual-use technology or strategic sectors.

■ Export controls

The European Union and its member states at the national level should aim at revising and strengthening existing export controls. For this purpose, they should leverage the current momentum that is building in the West to better understand China's development of its strategic sectors, as well as which actors and policies are involved. In areas or sectors where Beijing's policies and investments are found to be disconcerting in nature and seek to ultimately use European dual-use technology for China's military modernisation, diplomatic and economic action should be publicly taken by the EU and its member-state governments to block related exports. Coordinating these responses and export control mechanisms with like-minded countries such as Australia, New Zealand and the US will add greater weight to European actions and build a stronger coordinated voice against dual-use exports when needed. For this, a common understanding of 'dual-use' needs to be agreed upon between like-minded governments, with input from industry and research stakeholders.

■ Improve cyber defences

Cyber security should be a continued focus at the European Union, national government, academic research and industry levels. In addition to setting norms for cyber security and recommendations for cyber-security training, the focus should also be on resilience in general. Cooperation between governments and the private sector will be key here and should contribute to the reduction of Chinese and other foreign actors' intrusions into European networks for the purpose of cyber espionage. Greater understanding should be sought of China's offensive and defensive cyber capabilities and of which actors within China's system hold specific responsibilities related to cyber offensives aimed at European universities, industry and government.

■ Research cooperation with China

Continued cooperation on research into emerging technologies should be encouraged, as should be the access of foreign students to academic institutions in Europe that work on these issues. A more nuanced focus on the part of the EU and its member states, however, is needed. The EU should determine which specific sectors are too sensitive or critical to Europe's interests and security and either limit or restrict access to them. Furthermore, cooperation agreements with

Chinese partners should include very clear guidelines on data sharing and on the ownership of various patents and projects.

5.2 Promoting European innovation and R&D in dual-use technologies

■ Launch a strategic assessment process at the EU level

The European Union should leverage its competitive advantages and start a strategic assessment of the future technological needs of Europe's economies, industries and militaries, which should then guide any future policies to promote the development of European dual-use technologies and protect European innovation. This process should be led by the EU in order to coordinate various member states' existing strategies and goals, pool resources and avoid the wasteful duplication of work and initiatives. Achieving buy-in and participation from industry and the various member-state governments will also be key to the success of this initiative. The ultimate goal of this process would be to come up with an EU-wide plan to pursue the development of dual-use technologies that is based on Europe's goals, interests and vision of the future, instead of trying to catch up with or replicate China's – or the United States' – policies and strategies.

■ Set up an EU-wide initiative to provide funding for research into dual-use technologies

In the area of funding, the European Union and its member states can take inspiration from the Chinese and American examples. Establishing funding initiatives to increase the financial capital and investment available to the dual-use or emerging technology sectors will be a necessary lifeline for private sector innovation in the EU. Some funding is already available through the EU's Horizon 2020 innovation fund, European Structural Funds and the new European Defence Fund, but while some of these options are promising, not one of them is dual-use technology specific and they often involve lengthy, slow processes in order to access funding, which can deter potential participants. Government-led project work with funding attached to specific programmes, like that of the Apollo or the Manhattan projects in the past, could bring together multiple innovative stakeholders and maximise budgets if operating under financial constraints. Incentives such as tax breaks for certain strategic sectors vital to emerging technologies would also encourage increased activity and innovation.

■ Invest in education in the high-tech sector

Key to supporting continued innovation will be building and growing the necessary skilled workforce of the future. Investment in high-tech education, starting at a younger age through secondary school programmes up through university, will be vital to achieve this. Though such investments already exist, further policies could be considered. For example, internships and apprenticeships at younger ages in key technological sectors could be promoted through government-industry initiatives. Furthermore, an Erasmus-like programme could be developed between R&D centres in like-minded countries and the EU member states. Cooperation between academia and the wider research community should be fostered in these ways in order to build trust and confidence.

The EU is currently facing this significant problem with a weak and divided posture, the result of which could be important ramifications for European industry, economy, defence and security far into the future. While the EU is taking steps towards protecting its innovation capacity across member states through an investment screening mechanism and by providing funding for science and technology innovation, these initiatives do not go far enough. The investment screening mechanism, for example, is currently a lax political arrangement that is voluntary in nature, and the available funding is insufficient to compete with the amounts of money invested by China in similar fields of research. The European Union and EU member states therefore need smart solutions to protect and promote European innovation potential for years to come.

Copying other countries' approaches will not work well in the European supranational context, not least because the differing levels and areas of national and EU competence have created a complicated web of national responsibility, burden sharing and EU-mandated obligations. This is not an impossible task, however, but one that requires a sound vision, with meat on its bones. Key to achieving the goal of protecting innovation on emerging dual-use technologies that may have security implications in the future is deciding what type of actor the European Union is today, and agreeing on a vision for the EU in ten, 20, or 30 years' time. Brexit will prove a challenge to assigning the political space needed to decide what this vision is, but it might also create a timely opportunity to do so. Ultimately, the European Union and its member states have a strong science and technological base, world-renowned private sector companies, a well-trained and educated research and development talent pool, and a host of impressive innovation initiatives already under their belt. Coming together to protect these achievements and potential in a thorough and coordinated manner should be a logical next step.

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